US009469364B2

(12) **United States Patent**
Banasky et al.

(10) **Patent No.: US 9,469,364 B2**
(45) **Date of Patent: Oct. 18, 2016**

(54) **FOLDABLE ELECTRIC BICYCLE**

(71) Applicant: **Ford Global Technologies, LLC**, Dearborn, MI (US)

(72) Inventors: **Lawrence Banasky**, Livonia, MI (US); **Mark Wisnewski**, Stockbridge, MI (US); **Morris Donald**, Westland, MI (US); **Mark Viergutz**, Canton, MI (US)

(73) Assignee: **FORD GLOBAL TECHNOLOGIES, LLC**, Dearborn, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 98 days.

(21) Appl. No.: **14/317,186**

(22) Filed: **Jun. 27, 2014**

(65) **Prior Publication Data**

US 2015/0375820 A1 Dec. 31, 2015

(51) **Int. Cl.**
B62K 15/00 (2006.01)
B62M 6/60 (2010.01)

(52) **U.S. Cl.**
CPC ***B62K 15/006*** (2013.01); ***B62M 6/60*** (2013.01)

(58) **Field of Classification Search**
CPC B62K 15/006; B62K 15/008; B62K 2204/00; B62M 6/60; B62M 7/12
USPC 280/278, 287
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,267,401	B1 *	7/2001	De Jong	B62K 15/008 280/287
6,979,013	B2	12/2005	Chen	
8,523,212	B2 *	9/2013	Ryan	B62K 15/008 180/206.1
8,801,022	B2 *	8/2014	Song	B62K 15/006 280/278
2013/0277941	A1	10/2013	Ryan et al.	
2014/0076649	A1 *	3/2014	Kim	B62K 15/008 180/220

FOREIGN PATENT DOCUMENTS

CN	2825435	Y	10/2006	
CN	102431383	A	5/2012	
CN	202574557	U	12/2012	
EP	2176117	B1	3/2011	
GB	2414972	*	11/2004	
WO	2006131742	A1	12/2006	
WO	2010127456	A1	11/2010	
WO	2011107232	A1	9/2011	
WO	2015/011385	*	1/2015	B62K 3/10

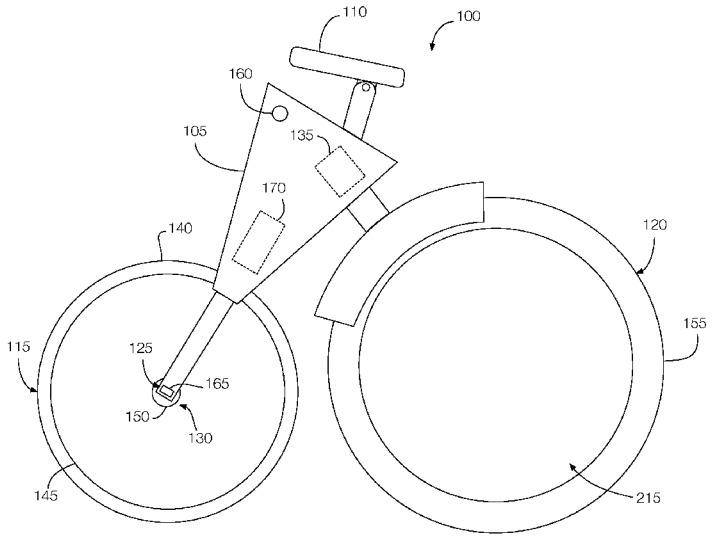
* cited by examiner

Primary Examiner — Anne Marie Boehler
(74) *Attorney, Agent, or Firm* — Frank A. MacKenzie; Bejin Bieneman PLC

(57) **ABSTRACT**

A foldable bicycle includes a frame, a front wheel assembly, and a rear wheel assembly. The frame defines a pivot axis. The front wheel assembly is disposed on the frame and configured to rotate about the pivot axis. The rear wheel assembly is disposed on the frame and defines an opening for receiving the front wheel assembly when the bicycle is folded.

15 Claims, 3 Drawing Sheets



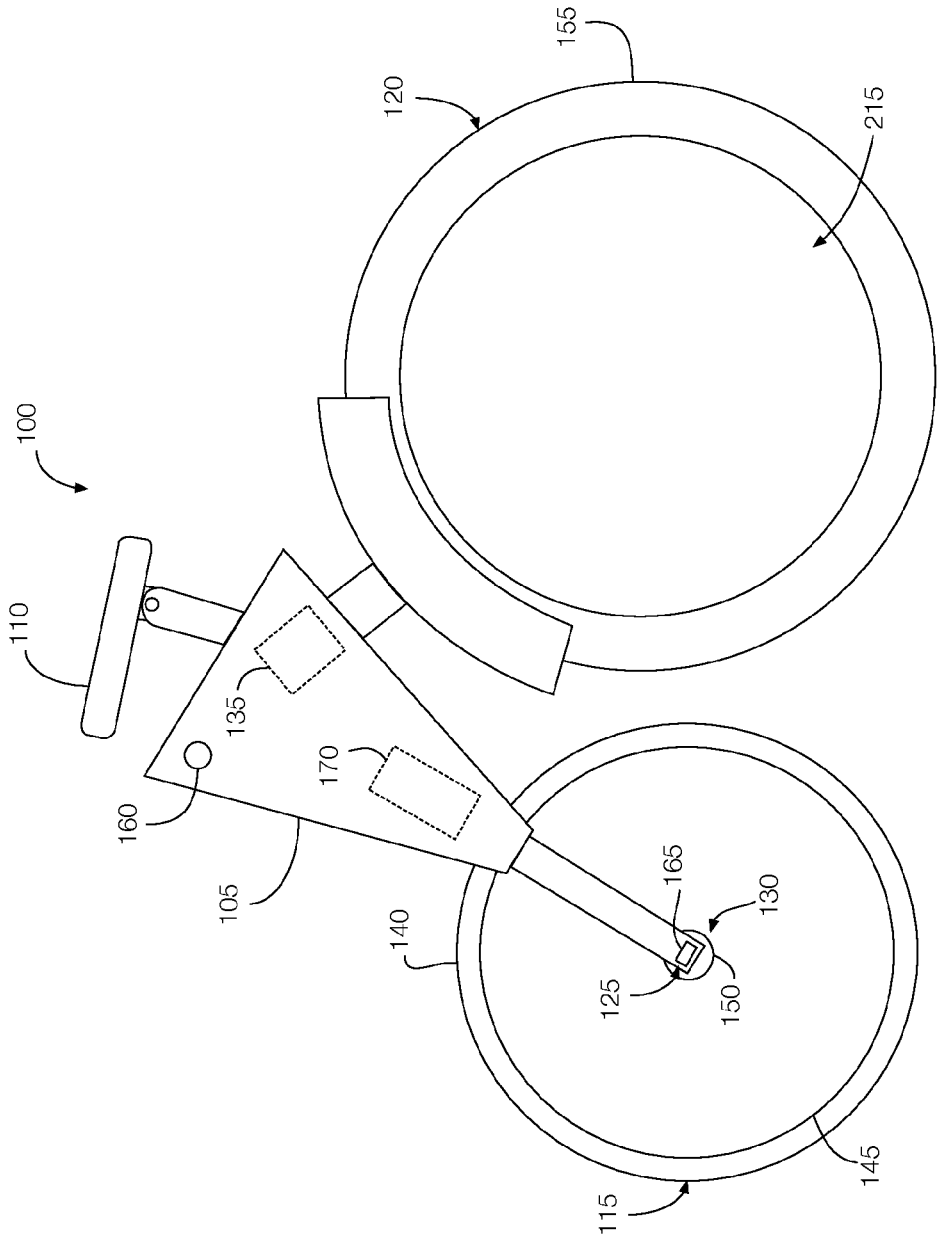


FIGURE 1

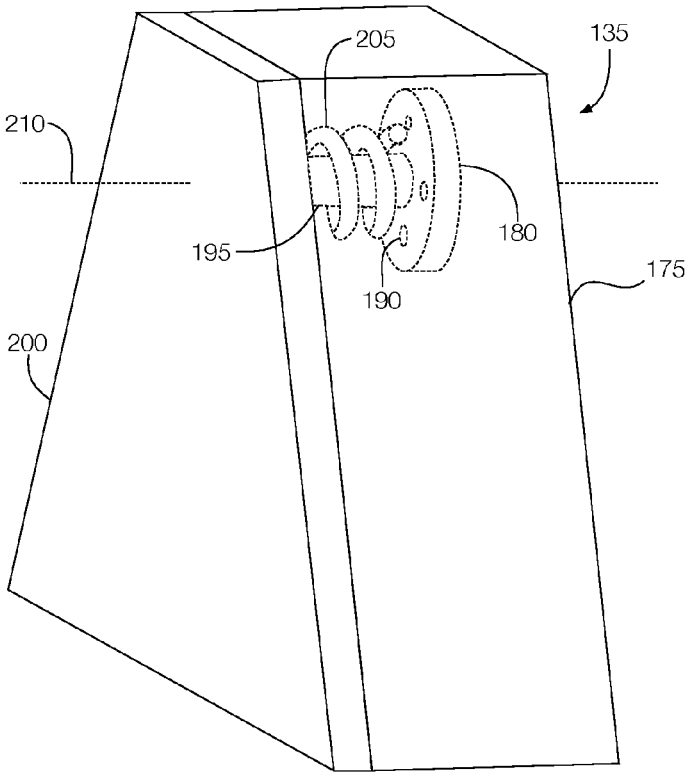


FIGURE 2A

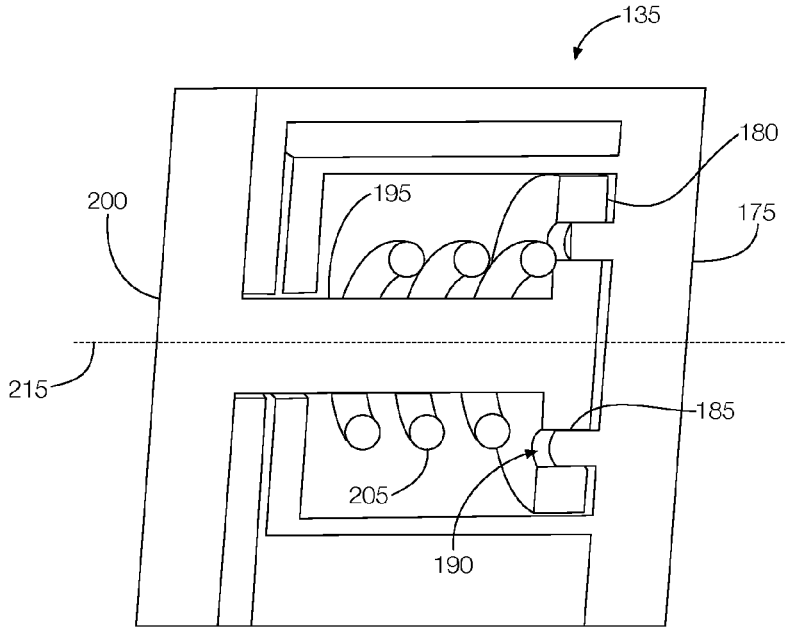


FIGURE 2B

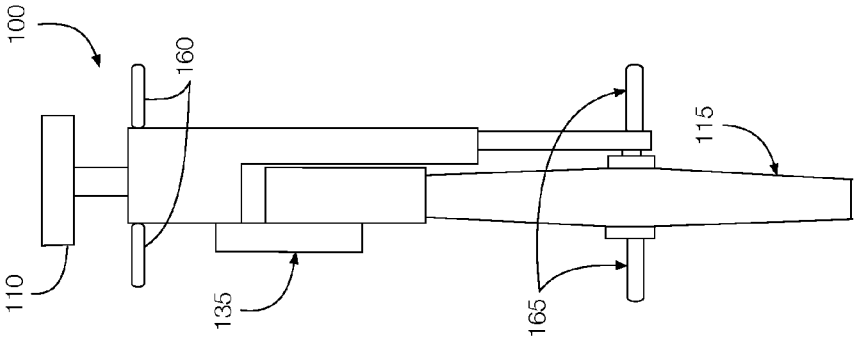


FIGURE 3C

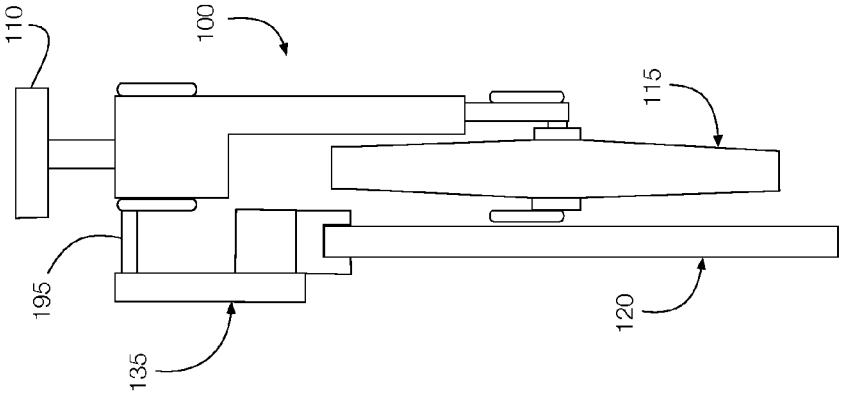


FIGURE 3B

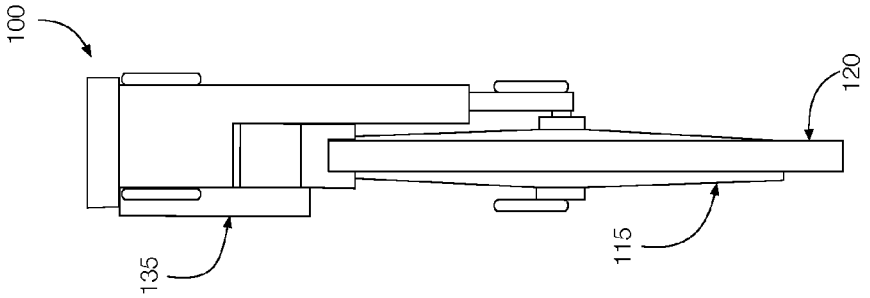


FIGURE 3A

FOLDABLE ELECTRIC BICYCLE

BACKGROUND

Bicycles are hard to transport with passenger vehicles, especially cars. Bicycles do not fit in the trunks of most vehicles unless the bicycle is disassembled. Reassembling a bicycle can take significant time, however. A common solution is to put the bicycle on a bike rack that attaches to the vehicle. Bike racks usually rest on the roof or trunk of the vehicle. Some bike racks attach to a trailer hitch. Even bike racks have drawbacks, however. For example, bike racks that attach to the trunk or trailer hitch often limit access to the trunk or cargo space.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an example foldable electric bicycle.

FIGS. **2**A and **2**B illustrate an example locking mechanism that may be used with the bicycle of FIG. **1**.

FIGS. **3**A-**3**C illustrate front views of the bicycle when in a folded, partially folded, and unfolded position.

DETAILED DESCRIPTION

Folding bicycles can be transported with passenger vehicles without having to disassemble the bicycle or put the bicycle on a bike rack. An example foldable bicycle includes a frame with a pivot and locking mechanism. The pivot and locking mechanism has a pivot housing and a locking housing. The pivot housing defines a pivot axis and the locking housing is configured to lock the frame into a folded position and an unfolded position. The bicycle further includes front and rear wheel assemblies. The front wheel assembly is configured to rotate about the pivot axis. The rear wheel assembly defines an opening having a diameter larger than an outer diameter of the front wheel assembly. Therefore, when the bicycle is in the folded position, the opening in the rear wheel assembly may receive the front wheel assembly, giving the bicycle a smaller footprint and making the bicycle easier to transport.

The bicycle and its elements shown in the FIGS. may take many different forms and include multiple and/or alternate components and facilities. The exemplary components illustrated are not intended to be limiting. Indeed, additional or alternative components and/or implementations may be used.

FIG. **1** illustrates a bicycle **100** that can be folded to fit in a cargo space of a vehicle, such as a car, truck, sport utility vehicle, van, minivan, or the like. The bicycle **100**, as shown, includes a frame **105**, a seat **110** disposed on the frame **105**, a front wheel assembly **115**, a rear wheel assembly **120**, a steering system **125**, and a drive system **130**.

The frame **105** may support several components of the bicycle **100**. For instance, the front and rear wheel assemblies **115**, **120** may be disposed on the frame **105**. Moreover, the frame **105** may further include a pivot and locking mechanism **135**, discussed in greater detail below with reference to FIGS. **2**A and **2**B. The pivot and locking mechanism **135** may define a pivot axis **210** for folding the bicycle **100**. Further, the pivot and locking mechanism **135** may lock the bicycle **100** in the folded position, the unfolded position, or both.

The front wheel assembly **115** may include a front wheel **140**, a hub **145** disposed within the front wheel **140**, and a motor **150** operably connected to the hub **145**. The motor **150** may be configured to receive electrical power and output a torque in accordance with the electrical power received. The torque generated by the motor **150** may drive the front wheel **140**. Accordingly, the front wheel **140** may rotate in accordance with the rotation of the motor **150**. The front wheel assembly **115** may be disposed on the frame **105**.

The rear wheel assembly **120** may include a spokeless rear wheel **155** rotatably connected to the frame **105**. The rear wheel **155** may define an opening **215** configured to receive the front wheel assembly **115** when the bicycle **100** is in the folded position (e.g., when the front wheel assembly **115** is rotated about the pivot axis **210**). The diameter of the opening **215**, therefore, may be larger than an outer diameter of the front wheel **140**.

The steering system **125** may be configured to help a rider steer the bicycle **100**. The steering system **125** may include handlebars **160**, footrests **165**, or both. The handlebars **160** may be disposed on the frame **105** near the seat **110**. During use, the rider may grip the handlebars **160** while seated. The handlebars **160** may include controls for receiving commands, inputs, or both, associated with the operation of the bicycle **100**. Therefore, the handlebars **160** may permit the rider to adjust the speed of the bicycle **100** or provide inputs to various systems such as a navigation system, an infotainment system, etc. In addition or in the alternative, the handlebars **160** may help steady the rider on the bicycle **100**. The footrests **165** may further support the rider. When not in use, the footrests **165** may be configured to fold toward the front wheel assembly **115**. The bicycle **100** may be steered by the rider manipulating the handlebars **160** or footrests **165**, or by leaning in a certain direction. In some instances, one or more gyroscopes may detect whether the rider is leaning. The gyroscope measurements may prompt the system to command the front wheel assembly **115** to turn in the direction in which the rider is leaning and adjust the speed of the motor **150** to assist with balance. The gyroscopes may be disposed in the frame **105**.

The drive system **130** may be configured to power the bicycle **100**. For instance, the drive system **130** may include a rechargeable battery **170** disposed in the frame **105**. Plugging the battery **170** into a power source, such as a wall outlet, may recharge the battery **170**. Alternatively or in addition, the drive system **130** may incorporate a regenerative braking technique to help charge the battery **170**.

The bicycle **100** may incorporate other features such as a navigation system and an infotainment system.

The navigation system may be configured to determine a position of the bicycle **100** using, e.g., a Global Positioning System (GPS) receiver that is able to triangulate the position of the bicycle **100** relative to satellites or terrestrial based transmitter towers. The navigation system may be further configured to develop routes from the current location to a selected destination, as well as display a map and present driving directions to the selected destination via, e.g., a user interface device.

The infotainment system may be configured to provide the rider with information related to the operation of the bicycle **100**. Such information may include a distance traveled, the amount of battery charge remaining, bicycle **100** speed, or the like. The infotainment system may also be configured to communicate with a rider's mobile device, such as a cell phone. For example, the infotainment system and the mobile device may pair with one another using a protocol such as, e.g., Bluetooth®. While paired, the mobile device and infotainment system may exchange information. In some possible approaches, the infotainment system includes an input device, an output device, or both. For

instance, the infotainment system may include a touch sensitive display screen configured to receive user inputs and present information to the user.

FIGS. **2**A and **2**B illustrate an example pivot and locking mechanism **135**. FIG. **2**B is a cross-sectional view of the pivot and locking mechanism of FIG. **2**A. As illustrated, the pivot and locking mechanism **135** includes a locking housing **175** configured to receive a base **180**. For example, the locking housing **175** may include pins **185** configured to engage holes **190** defined by the base **180**. A shaft **195** may be disposed on or integrally formed with the base **180** at one end. At another end, the shaft **195** may be disposed on or integrally formed with a pivot housing **200**. The shaft **195**, therefore, may extend from the pivot housing **200** into the locking housing **175**. A spring **205** may be configured to bias the base **180** toward the locking housing **175**. Specifically, the spring **205** may keep the base **180** engaged with the pins **185** of the locking housing **175**. As shown, the spring **205** is aligned with the shaft **195**. Alternatively, the spring **205** may be disposed substantially parallel to the shaft **195**.

To move the bicycle **100** from the unfolded position to the folded position, and vice versa, the base **180** must be disengaged from the pins **185**. One way to disengage the base **180** from the pins **185** may include counteracting the force of the spring **205**. For instance, a rider or other person could pull the pivot housing **200** away from the locking housing **175**, causing the spring **205** to compress and the base **180** to disengage the pins **185**. The pivot housing **200** may be rotated about, e.g., an axis **210** defined by the shaft **195**. Once the bicycle **100** is in the new position (i.e., the folded or unfolded position), releasing the pivot housing **200** will cause the spring **205** to push the base **180** back into engagement with the pins **185**.

FIGS. **3**A-**3**C illustrate front views of the bicycle **100** as it moves from the folded position to the unfolded position.

In FIG. **3**A, the front wheel assembly **115** is disposed within the rear wheel assembly **120**. Although not viewable in FIG. **3**A, the spring **205** is biasing the base **180** toward the pins **185** in the locking housing **175**. Moreover, the footrests **165** are folded toward the front wheel assembly **115** while the bicycle **100** is in the folded position. In the folded position, the bicycle **100** has a relatively flat profile, making the bicycle **100** easy to transport in a vehicle. The small footprint allows the bicycle **100** to be easily stowed in a trunk, in or behind a back seat, or on the roof of a vehicle.

FIG. **3**B illustrates the front view after the pivot housing **200** is pulled away from the locking housing **175**. Pulling the pivot housing **200** compresses the spring **205** and releases the base **180** from the pins **185**. The frame **105** is now free to rotate about the axis **210** defined by the shaft **195**.

FIG. **3**C illustrates an example front view of the bicycle **100** in the unfolded position. The pivot and locking mechanism **135** keeps the bicycle **100** in the unfolded position. That is, the spring **205** pushes the pivot housing **200** toward the locking housing **175**, causing the base **180** to engage the pins **185**. The bicycle **100** cannot be moved out of the unfolded position until the pins **185** are disengaged.

In general, the computing systems and/or devices discussed above may employ any of a number of computer operating systems, including, but by no means limited to, versions and/or varieties of the Ford Sync® operating system, the Microsoft Windows® operating system, the Unix operating system (e.g., the Solaris® operating system distributed by Oracle Corporation of Redwood Shores, Calif.), the AIX UNIX operating system distributed by International Business Machines of Armonk, N.Y., the Linux operating system, the Mac OS X and iOS operating systems distributed by Apple Inc. of Cupertino, Calif., the BlackBerry OS distributed by Research In Motion of Waterloo, Canada, and the Android operating system developed by the Open Handset Alliance. Examples of computing devices include, without limitation, an on-board vehicle computer, a computer workstation, a server, a desktop, notebook, laptop, or handheld computer, or some other computing system and/or device.

Computing devices generally include computer-executable instructions, where the instructions may be executable by one or more computing devices such as those listed above. Computer-executable instructions may be compiled or interpreted from computer programs created using a variety of programming languages and/or technologies, including, without limitation, and either alone or in combination, Java™, C, C++, Visual Basic, Java Script, Perl, etc. In general, a processor (e.g., a microprocessor) receives instructions, e.g., from a memory, a computer-readable medium, etc., and executes these instructions, thereby performing one or more processes, including one or more of the processes described herein. Such instructions and other data may be stored and transmitted using a variety of computer-readable media.

A computer-readable medium (also referred to as a processor-readable medium) includes any non-transitory (e.g., tangible) medium that participates in providing data (e.g., instructions) that may be read by a computer (e.g., by a processor of a computer). Such a medium may take many forms, including, but not limited to, non-volatile media and volatile media. Non-volatile media may include, for example, optical or magnetic disks and other persistent memory. Volatile media may include, for example, dynamic random access memory (DRAM), which typically constitutes a main memory. Such instructions may be transmitted by one or more transmission media, including coaxial cables, copper wire and fiber optics, including the wires that comprise a system bus coupled to a processor of a computer. Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, a RAM, a PROM, an EPROM, a FLASH-EEPROM, any other memory chip or cartridge, or any other medium from which a computer can read.

Databases, data repositories or other data stores described herein may include various kinds of mechanisms for storing, accessing, and retrieving various kinds of data, including a hierarchical database, a set of files in a file system, an application database in a proprietary format, a relational database management system (RDBMS), etc. Each such data store is generally included within a computing device employing a computer operating system such as one of those mentioned above, and are accessed via a network in any one or more of a variety of manners. A file system may be accessible from a computer operating system, and may include files stored in various formats. An RDBMS generally employs the Structured Query Language (SQL) in addition to a language for creating, storing, editing, and executing stored procedures, such as the PL/SQL language mentioned above.

In some examples, system elements may be implemented as computer-readable instructions (e.g., software) on one or more computing devices (e.g., servers, personal computers, etc.), stored on computer readable media associated therewith (e.g., disks, memories, etc.). A computer program

product may comprise such instructions stored on computer readable media for carrying out the functions described herein.

With regard to the processes, systems, methods, heuristics, etc. described herein, it should be understood that, although the steps of such processes, etc. have been described as occurring according to a certain ordered sequence, such processes could be practiced with the described steps performed in an order other than the order described herein. It further should be understood that certain steps could be performed simultaneously, that other steps could be added, or that certain steps described herein could be omitted. In other words, the descriptions of processes herein are provided for the purpose of illustrating certain embodiments, and should in no way be construed so as to limit the claims.

Accordingly, it is to be understood that the above description is intended to be illustrative and not restrictive. Many embodiments and applications other than the examples provided would be apparent upon reading the above description. The scope should be determined, not with reference to the above description, but should instead be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. It is anticipated and intended that future developments will occur in the technologies discussed herein, and that the disclosed systems and methods will be incorporated into such future embodiments. In sum, it should be understood that the application is capable of modification and variation.

All terms used in the claims are intended to be given their ordinary meanings as understood by those knowledgeable in the technologies described herein unless an explicit indication to the contrary is made herein. In particular, use of the singular articles such as "a," "the," "said," etc. should be read to recite one or more of the indicated elements unless a claim recites an explicit limitation to the contrary.

The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

The invention claimed is:

1. A foldable bicycle comprising:

a frame defining a pivot axis and a pivot and locking mechanism that includes a base, a locking housing that receives the base, and a pivot housing;

a front wheel assembly disposed on the frame and configured to rotate about the pivot axis; and

a rear wheel assembly disposed on the frame and defining an opening,

wherein the front wheel assembly is disposed within the opening defined by the rear wheel assembly when the bicycle is in a folded position,

wherein the pivot housing and the base engage the locking housing when the bicycle is in the folded position and in an unfolded position,

wherein the base defines holes and wherein the locking housing includes pins configured to engage the holes of the base.

2. The foldable bicycle of claim **1**, wherein the pivot axis is defined by the pivot and locking mechanism.

3. The foldable bicycle of claim **1**, wherein the pivot and locking mechanism is configured to lock the bicycle in at least one of the folded position and the unfolded position.

4. The foldable bicycle of claim **1**, wherein the pivot and locking mechanism includes a shaft disposed on the base.

5. The foldable bicycle of claim **4**, wherein the shaft extends from the pivot housing and into the locking housing.

6. The foldable bicycle of claim **4**, wherein the pivot and locking mechanism includes a spring configured to bias the base toward the locking housing.

7. The foldable bicycle of claim **6**, wherein the spring is coaxially aligned with the shaft.

8. The foldable bicycle of claim **6**, wherein the spring is substantially parallel to the shaft.

9. The foldable bicycle of claim **1**, wherein the front wheel assembly includes:

a front wheel;

a hub disposed within the front wheel; and

a motor operably connected to the hub.

10. The foldable bicycle of claim **9**, wherein a diameter of the opening defined by the rear wheel assembly is larger than an outer diameter of the front wheel.

11. The foldable bicycle of claim **1**, wherein the rear wheel assembly includes a spokeless rear wheel rotatably connected to the frame, wherein the opening is defined by the rear wheel.

12. A foldable bicycle comprising:

a frame having a pivot and locking mechanism including a base, a pivot housing, and a locking housing that receives the base, wherein the pivot housing defines a pivot axis and wherein the locking housing is configured to lock the frame into at least one of a folded position and an unfolded position;

a front wheel assembly disposed on the frame and configured to rotate about the pivot axis; and

a rear wheel assembly disposed on the frame and defining an opening having a diameter larger than an outer diameter of the front wheel assembly,

wherein the front wheel assembly is disposed within the opening defined by the rear wheel assembly when the bicycle is in a folded position,

wherein the pivot housing and the base engage the locking housing when the bicycle is in the folded position and in the unfolded position,

wherein the base defines holes and wherein the locking housing includes pins configured to engage the holes of the base.

13. The foldable bicycle of claim **12**, wherein the pivot and locking mechanism includes a shaft disposed on the base and extending from the pivot housing into the locking housing.

14. The foldable bicycle of claim **13**, wherein the pivot and locking mechanism includes a spring configured to bias the base toward the locking housing.

15. The foldable bicycle of claim **12**, wherein the rear wheel assembly includes a spokeless rear wheel rotatably connected to the frame, wherein the opening is defined by the rear wheel.

* * * * *